

# 变化的气候与变化的城市设计策略

## CHANGING CLIMATE AND CHANGING STRATEGIES FOR URBAN DESIGN



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### 摘要

全球气候变化对人类社会和经济建设产生了广泛而深刻的影响。作为气候变化最显著的特征之一，海平面上升会加剧沿海地区的风暴潮、海岸侵蚀、海水入侵等海洋灾害的发生，严重威胁沿海地区的社会经济发展。本次受访者为全球气候变化领域的专家，其在访谈中指出海洋在全球气候系统中占据主导地位，在全球气候变化过程中亦发挥着重要作用，并进一步分析了全球海平面上升的非同步性和非平均性。受访者指出全球气候变化的基础研究成果还有待转换到气候学、灾害预报与防控、城市规划与设计等应用学科领域，以为沿海地区城市建设的风险评估和管理提供指导。

### 关键词

海洋；全球气候变化；海平面上升；城市设计

### ABSTRACT

Global climate change has a broad and profound impact on human social and economic development. As one of the most distinguishing observations of climate change, sea level rise exacerbates marine disasters such as storm surge, coastal erosion, and seawater intrusion, which threaten the socio-economic development of coastal areas. As an expert on global climate change, the interviewee noted that ocean plays an absolutely dominant role in global climate system, and further emphasized the non-synchronicity and non-uniformity of global sea level rise. He also pointed out that basic research on global climate change needs to be more extensively applied in climatology, disaster prediction and control, urban planning and design, and other disciplines, in order to provide scientific support on risk assessment and management for urban construction of coastal regions.

### KEY WORDS

Ocean; Global Climate Change; Sea Level Rise; Urban Design

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### 海洋在全球气候变化中扮演着怎样的角色？

**陈显尧（以下简称陈）：**我的研究结果显示，海洋在全球气候变化中起着至关重要的作用。其中最主要的原因是海洋的热含量很大，全球气候系统所吸收热量的90%以上为海洋所吸收，因此海洋在气候系统的能量平衡中占主导地位。也正因为这种主导地位，海洋环流的变异会影响气候系统中的热量“分配”，从而影响海表面温度的变化，进而影响我们所能感受得到的气候变化。例如，在1998~2012年间，虽然温室气体仍然持续加速排放，但是全球平均表面温度的上升速度有所减缓，有人因此质疑温室气体是否会导致全球变暖，还有人质疑是否因为中国经济快速发展过程中排放的气溶胶阻隔了到达地表的净热辐射，等等。但我们通过分析观测数据发现，这并不是全球变暖“停”了，而是海洋通过环流变异将更多的热量输送到了中深层（200m以深），减缓了海表面温度的上升速度。而这也进一步说明，当海洋环流变化到不利于向中深层海洋输送热量的状态时，在当前温室气体排放的背景下，海表面温度就会明显上升。这些结果说明了海洋对气候变化的重要影响。当然，地球气候系统中的各个组成部分，包括大气圈、冰冻圈和水圈等，都并不是相对独立的，它们有机地、紧密地联系在一起。因此，海洋的

变化也是与其他各个圈层之间复杂相互作用的结果。目前人类对这些过程的了解仍然十分有限，有待展开更加深入的研究。我想强调的是，我们需要重视海洋在整个气候系统中的主导地位，及其在全球气候变化过程中所发挥的重要作用。

### 在全球尺度上来说，海平面上升是否存在非同步性和非均匀性？

**陈：**是的，我们现在所说的全球海平面上升是平均意义上的。一个是指变化速率上的平均，一个是指时间尺度上的平均。我们的研究通常是以年际为时间尺度，全球平均海平面上升速率通常是一年几毫米。

地球上水的总量基本上是不变的，在不同的时间尺度上，海洋的变化和作用也不一样。举例来说，一次厄尔尼诺过程的影响可能会在几个月内引起海平面产生几厘米的变化。2011年是一个很强的拉尼娜年，当年全球气候的一个主要特征是全球陆地的降雨显著增加，即海洋蒸发量增大，水被输送到陆地上，这个量值是非常巨大的——根据科学家估算，这些蒸发并降落到陆地上的水，致使全球平均海平面在一年左右的时间下降了约5cm；降落到陆地上的水在随后的4~5个月内通过径流、蒸发、渗透等作用返回到海洋，全球海平面高度才得以恢复。分析研究结果显示，中国沿海海平面变化受厄尔尼诺/

拉尼娜事件影响明显。2015年厄尔尼诺事件盛期，中国沿海海平面总体低于相邻年份；2016年4月厄尔尼诺事件结束，夏季热带太平洋转为拉尼娜状态，中国沿海海平面达到了历史新高，较2015年高38mm。<sup>[1]</sup>这种强拉尼娜事件所带来的剧烈的海平面从负到正的变化超出了我们所说的全球平均速度。

### 气候变化问题往往与政治、经济，甚至国家利益联系在一起，已经超出了单纯的科学范畴。请问您如何看待气候变化问题背后的种种舆论现象？

**陈：**从科学上讲，我个人认为我们还没有完全了解气候变暖的整个过程，还不能完全确定人类活动对气候变化的影响作用。1998~2012年全球气候变暖“减缓”就是自然界为我们提供的一个例证。2015年，《科学》杂志曾发表文章，指出气候系统的自然变率可能在任何时候超过人类活动的影响。科学研究是为了提高气候变化的预测能力，但绝大多数气候模型由于受限于观测和认识水平，尚且无法成功模拟和预测这一现象，这说明目前的气候模型还不能很好地模拟人类活动和自然变率之间的关系，仍需要开展深入的研究。

尽管科学界对气候变化问题的关注比较谨慎，但某些个人、机构，甚至包括一些政治团体在这些预测成果并不一定完全正确的

前提下对其进行过度解读：他们并非从科学客观的角度出发，而是结合了当时的某种政治、经济或利益需求，选取了科学结论中对其有利的研究成果。这种解读也往往缺乏时间维度概念，例如，2012年海平面变化数据显示那一年的海平面呈下降状态，而2013年海平面变化又恢复了上升态势；但如果有人单拿出某一年的数据就说海平面变化呈上升或下降趋势，就会对公众产生误导。

**沿海区域是城市规划与设计的热点对象之一，城市也在向海洋持续扩张、索取空间。您认为诸如海平面上升等与气候变化相关的科学研究成果如何对城市弹性设计产生切实的指导意义？**

**陈：**海洋科学研究的成果对沿海城市的规划与发展具有重要的指导意义。海洋变化的时间尺度一般都很长，有些变化的准周期超过10年、20年，其影响是缓慢积累起来的。在积累到一定程度之前，大家很难注意到它的作用，而一旦注意到，通常已经具有了巨大的灾害性，并会持续较长时间。

海平面上升就是这样的例子：我们关于海平面上升的研究得出的数据是一年上升几毫米，一些城市设计师可能觉得这个数据很小，这项研究成果对城市沿海地区建设的影响不大，他们认为可以通过设计冗余（比如将工程构筑加高数米）来一劳永逸地涵盖百年一遇的灾害影响。但是，海平面上升是一种缓发性灾害，其长期累积效应会加剧风暴

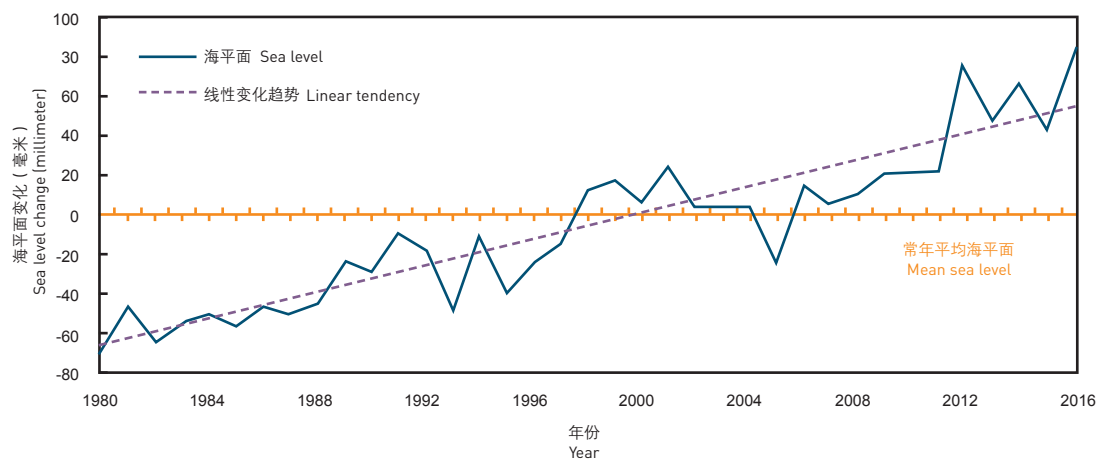
潮、海岸侵蚀、海水入侵和咸潮等灾害，削弱沿海防潮排涝基础设施功能，加大高海平面期间发生的强降雨和洪涝的致灾程度。<sup>[1]</sup>

近海观光、特色海岛旅游，以及以休闲游艇停泊码头为主的港口建设将成为沿海地区城市日益重要的未来开发方向。但低海拔沿海地区是气候变化的脆弱区，其中滨海城市和滨海低地更易受到海平面上升的直接影响。《2016年中国海平面公报》指出，2016年，受气候变化和海平面上升累积效应等多种因素的影响，辽宁、河北和海南等省的海岸侵蚀范围加大，辽宁、河北和山东等省的海水入侵较重，高海平面加剧了浙江、福建和广东等地的风暴潮与洪涝灾害。<sup>[1]</sup>因此，《公报》指出，应根据不同地块的自然环境

特点与经济社会属性制定海平面上升应对策略：滨海城市经济发达、人口密集，应重点从防潮排涝、供水安全和控制地面沉降三个方面采取措施；滨海低地拥有多样的生态系统、丰富的滩涂资源和漫长的自然海岸，应从生态保护、滩涂利用和海岸防护三个方面采取措施。<sup>[1]</sup>

因此，针对沿海城市的规划设计和未来发展，我认为规划师和设计师需要充分了解海洋的变化及其影响，一个不适宜的设计方案会对城市的长期发展带来不利影响，而修改这种影响作用会付出更大的代价。我希望将我们的基础研究转换到气候、灾害预报与防控，城市规划与设计等应用学科领域，去指导相关实践，并转译为公众更容易了解的内容。**LAF**

1. 1980-2016年中国沿海海平面变化
1. China's coastal sea level change from 1980 to 2016



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**What role does the ocean play in global climate change?**

**Xianyao CHEN (CHEN hereafter):** My findings demonstrate that the ocean plays a dominant role in global climate change. One of the most important reasons is the enormous heat capacity of ocean — more than 90% of the thermal absorption of the whole global climate system is stored in the oceans, which, thus, impacts the energy balance of global climate system. For this reason, the variation of the ocean circulation impacts the thermal distribution of the climate system, which further impacts the change of sea surface temperature, resulting in climate change that we can perceive. For example, between 1998 and 2012, although greenhouse gas emission had continued to increase, the speed of global average surface temperature rising had slowed down. Some therefore questioned whether greenhouse gases would lead to global warming or not, and some argued that the emission of aerosols caused during China's rapid economic development blocked the net heat radiation reaching the surface. However, by analyzing the observed data, we found that the global warming had not “stopped,” instead, oceans transported more heat into the mid-deep layer (200 m and deeper)

through the circulation variation, which slowed the rising speed of sea surface temperature. These findings also suggest that if the variation of ocean circulation is not favour for the heat transport into the mid-deep ocean, the surface temperature would rise noticeably according to the current greenhouse gas emissions. This also demonstrates the significant impact of oceans on climate change. Of course, all the components of the Earth's climate system, including the atmosphere, cryosphere, hydrosphere, etc., are organically and closely linked with each other. Thus, the changes of oceans are the result from the complex interactions with other spheres. Our understanding of these processes is very limited and still requires in-depth research. What I would like to emphasize is that we need to realize the dominant role oceans play in the climate system, as well as in the process of global climate change.

**Is there any non-synchronicity or non-uniformity in terms of sea level rise on the global scale?**

**CHEN:** Yes, the global sea level rise we are now talking about is in an average sense in terms of the rising rate and the time dimension. Our research is usually conducted on an interannual

scale, where the global sea level rise rate averages a few millimeters per year.

The total amount of water on the Earth stays basically a constant, while in different time scales, oceans' change and impact varies. For example, the impact of an El Niño process may cause a few centimeters change in sea level within a few months. In 2011, a very strong La Niña phenomenon occurred, resulting in a significant increase in global terrestrial rainfall (increased ocean evaporation transferred water to the land). The total rainfall amount was extremely huge — according to scientific estimation, the water evaporated from the ocean and fell on land caused a global average sea level falling by approximately 5 centimeters within the year; the water then returned back to the ocean in the following four or five months through runoff, evaporation and penetration. Relevant research shows that China's coastal sea level changes are greatly impacted by El Niño / La Niña events. In 2015, the peak year of the El Niño event, China's coastal sea level was relatively lower, compared with surrounding years. After April 2016, when the El

Niño event ended, the tropical Pacific during June to September turned to the La Niña state, when the coastal sea level in China reached a record high level, 38 millimeters higher than that of in 2015<sup>[1]</sup>. This kind of intense sea level change far exceeded what the global average speed.

**Far beyond the scope of science, the issue of climate change is often debated with politics, economy, and even national interests. How do you consider the various factors behind the issue of climate change?**

**CHEN:** From a scientific perspective, I do not believe that we have fully understood the process of global warming; we cannot clearly determine the impact of human activities on climate change, either. The slowdown of the global warming from 1998 to 2012 is an exact proof. In 2015, an article published on *Science* stated that the natural variability of the climate system could exceed the impact of human activities at any time. All scientific researches aim at improving human's capacity in prediction of climate change. However, due to limited observation condition and awareness,

most of current climate models are not able to accurately simulate or predict global warming and the correlation between human activities and natural variability, which requires more in-depth study in future.

Unlike the scientific community's cautiousness on the issue of climate change, some individuals, institutions, or even political groups, have over-interpreted these research findings and predictions which yet cannot be seen as completely reliable results in a scientific sense. For certain political or economic interests, their arguments are lopsided and often ignore the time dimension. For example, the research on sea level change shows that the global sea level declined in 2012 and rose in 2013; if someone comes up with a conclusion of either rising or declining sea level change trend only based on the data of one single year, the fallacy would mislead the public.

**Coastal area is one of the main subjects in urban planning and design, and cities continue to expand to the seashore. In your opinion, how should researches related to climate change, including studies on sea-level rise, provide practical guidance on urban resilience design?**

**CHEN:** The results of marine scientific research have important guiding significance for the planning and development of coastal cities. The time scale of oceanic change is quite long — some changes take more than 10 years or 20 years — the impact of oceanic change is, thus, a slow accumulation process which is difficult for us to notice or observe until it causes huge disasters with lasting impacts.

Sea level rise is such an example: our research shows that the sea level rising speed is usually a few millimeters per year. Some designers consider it as a negligible result and such studies can hardly influence their planning decision on the urban development and construction in coastal areas because they believe that the impact of a hundred-year disaster could be easily withstood by building engineering structures with a few meters higher than the norm. However, the rise of sea level often causes latent disasters with long-term accumulative effect that would aggravate storm surge, coastal erosion, sea water intrusion, salt tide, and other disasters, weaken the performance of coastal tide prevention and drainage infrastructures, and

exacerbate the intension and damage of strong rainfall and flood occurred in the high-sea-level days.<sup>[1]</sup>

Offshore sightseeing, island tourism, and port construction for marina use are increasingly important development directions to coastal areas. However, low-lying coastal areas are vulnerable to climate change, particularly the coastal cities and coastal lowlands are more directly impacted by sea-level rising. 2016 China Sea Level Bulletin stated that in 2016, affected by accumulative factors of climate change and sea level rise, the coastal erosion area of Liaoning, Hebei and Hainan provinces worsened, Liaoning, Hebei and Shandong provinces suffered heavier sea water intrusion, and the high sea level aggravated storm surges and floods in Zhejiang, Fujian and Guangdong provinces.<sup>[1]</sup> The Bulletin further suggested different strategies according to natural environmental conditions and social-economic characteristics: the development strategy for coastal cities with developed economy and dense population should focus on tide prevention and drainage, water supply safety, and land subsidence control; for coastal lowlands with diverse ecosystems, rich beach resources, and

long natural coasts, we should pay high attention to ecological preservation, beach use, and coastal consolidation.<sup>[1]</sup>

In conclusion, for the planning and development of coastal cities, I think planners and designers need to fully understand the oceanic changes and their impact. An inappropriate design could adversely affect the city's long-term development and even cause greater costs and damages. I hope that basic scientific researches could be applied to prediction and prevention of climate and disaster, urban planning and design, and other fields, offering guidance for the relevant practice and enhancing public awareness. **LAF**

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